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Beyond Motor Impairment Somatosensory Function and Body Awareness as Contributors to Activity Participation and Quality of Life in Children with Cerebral Palsy

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ABSTRACT

Purpose: Hemiplegic Cerebral Palsy (CP) in childhood is characterized not only by motor deficits but also by accompanying sensory and perceptual impairments. Despite the recognized importance of somatosensory functions and body awareness, their associations with activity, participation, and quality of life remain relatively unexplored within an ICF-oriented framework. This study aimed to investigate the associations between somatosensory functions, body awareness, and functional outcomes, including activity performance, participation, and quality of life, in school-aged children with hemiplegic CP.

Materials and methods: This cross-sectional study included 43 children with hemiplegic CP aged between 6 and 17 (12.65 ± 3.74) years. Somatosensory functions were assessed using the Semmes-Weinstein Monofilament Test for tactile perception, two-point discrimination with a calibrated esthesiometer, vibration perception with a tuning fork, proprioception with a goniometer, and stereognosis using standardized everyday objects. Body awareness was evaluated using a multisensory afferent model-based assessment including body schema, structural body representation, and body image tasks. Activity was assessed using the Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDI-CAT), participation using the Child Adolescent Scale of Participation (CASP), and quality of life using the KIDSCREEN-27.

Results: Following Holm correction, vibration perception, foot stereognosis, and body awareness were significantly associated with multiple PEDI-CAT domains ($\rho = 0.372–0.514$, $p < 0.05$). Body awareness demonstrated the strongest and most consistent associations with CASP participation

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domains (ρ = 0.362–0.697, $p < 0.05$), while vibration perception was also significantly associated with school participation (ρ = 0.400–0.404, $p < 0.05$). For KIDSCREEN-27, two-point discrimination, proprioception, and stereognosis were significantly associated with physical activities and health domain (ρ = −0.453–0.443, $p < 0.05$).

Conclusions: Body awareness and stereognosis were the somatosensory variables most consistently associated with activity, participation, and quality of life in school-aged children with hemiplegic CP. These findings suggest that higher-order sensory-perceptual functions may play a meaningful role in daily life functioning and may represent important targets for comprehensive rehabilitation strategies.

Key words: Hemiplegic cerebral palsy; Somatosensory functions, Body awareness; Activity and participation, Quality of life, School-aged

INTRODUCTION

Cerebral Palsy (CP) is a group of disorders that permanently affect the development of movement and posture, resulting from non-progressive abnormalities that occur during the development of the fetal or infant brain [1]. This is the most common cause of disability in childhood, but the severity of motor impairments and functional abilities vary depending on the underlying causes [2]. The International Classification of Functioning, Disability and Health (ICF) takes a holistic approach to functional outcomes, considering that impairment is not solely due to motor disorders, encompassing body function, activity, participation, and contextual factors. ICF model, improving the quality of life and social participation of individuals with CP requires a holistic approach to assess not only motor impairments but also sensory and cognitive functions [3].

Somatosensory inputs, including tactile perception, proprioception, and stereognosis, are essential for body awareness, motor planning, and functional performance, and impairments in these functions are common in children with CP [4]. In children with Hemiplegic CP, unilateral lesions in the brain cause asymmetric processing of somatosensory information, leading to impaired body awareness [5]. The literature reports that sensory processing problems are common in children with CP, that these problems often occur together with motor impairments, and that somatosensory inputs are an important determinant in the regulation and direction of movement [6].

In school-aged children with hemiplegic CP, limitations in activity, participation, and quality of life are multifactorial. According to ICF, impairments in body structures and functions, especially

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somatosensory dysfunction and altered body awareness, may substantially contribute to these limitations, with potential consequences for academic performance and broader life outcomes. Although several studies have investigated somatosensory functions in children with CP, research examining the relationship between these functions and activity, participation, and quality of life within the framework of ICF remains limited, particularly in school-aged children [7,8].

This study aimed to investigate the relationships between somatosensory functions, body awareness, and functional outcomes including activity performance, participation, and quality of life in school aged children with hemiplegic CP, within the framework of the ICF.

MATERIAL and METHODS

Participants

This study included children and adolescents aged 6-17 years diagnosed with hemiplegic CP, classified at levels I-II-III according to the Gross Motor Function Classification System (GMFCS) and the Communication Function Classification System (CFCS), and without cognitive impairment. Exclusion criteria included having received BoNT-A treatment or any extremity surgery within the last 6 months prior to evaluation, having any orthopedic or neurological problem on the unaffected side, having visual or auditory problems, and not agreeing to participate in the study. The parents/caregivers of all subjects of the study were informed about the study and provided informed, written consent before the subjects' participation in the study. The necessary permission and approval were obtained from the Hacettepe University Health Sciences Research Ethics Committee with decision number 24/139. All methods were performed in accordance with the relevant guidelines and regulations.

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The gender, age, affected limb sides, and functional classification levels of the individuals participating in the study were recorded. Within the scope of functional classifications, Manual Hand Skills Classification System (MACS), and Eating and Drinking Skills Classification System (EDACS) were used.

Somatosensory Functions Assessments

Tactile Perception

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Tactile perception was assessed using a 6-kit Semmes-Weinstein Monofilament Kit [Baseline®, Fold-Up Monofilaments, AJW Technology Consulting GmbH, Düsseldorf, 40215, (Germany)]. The evaluation area for the hand was the distal portion of the 1st and 5th phalanges and the palm, while for the foot it was the head of the 1st and 5th metatarsals and the heel on the plantar side of the foot. The lowest monofilament value perceived correctly in at least two out of three trials was recorded [9,10]. The Semmes-Weinstein Monofilament Test has demonstrated good to excellent test-retest reliability in children with hemiplegic CP (ICC = 0.79–0.96) [11].

Two Points Discrimination

A Discriminator [Baseline®, Fabrication Enterprises Inc., White Plains, NY, USA] was used to evaluate the distinction between the two points in same anatomical locations. For each region, the score was defined as the minimum distance (mm) between two stimulus points that were correctly identified as distinct points in two out of three trials [9,10]. Static two-point discrimination has shown excellent test-retest reliability in children with hemiplegic CP (ICC = 0.93) [11].

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Vibration

A 128 Hz tuning fork [Baseline®, Fabrication Enterprises Inc., White Plains, NY, USA] was used to evaluate the vibration sensation. The areas evaluated for the hand were the 1st and 5th proximal interphalangeal joints (PIP) and the styloid process of the ulna. For the foot, these were defined as the head of the 1st metatarsal, the medial and the lateral malleolus. Vibration in the evaluated areas was recorded in seconds (s), and the average of each of the three trials was taken. [9, 12]. The 128 Hz tuning fork is a reliable and valid clinical tool for evaluating vibration perception [13].

Proprioception

A goniometer was used to assess proprioception. In the upper extremity, shoulder flexion, extension, and abduction movements were evaluated, while in the lower extremity, hip flexion, extension, and abduction were assessed. Participants were first asked to complete the movement with their eyes open within their normal range of motion. Subsequently, participants were asked to perform half of the upper and lower extremity movements with their vision obstructed. The difference between half the range of motion performed with their eyes closed and half the range of motion performed with their vision obstructed was recorded as the margin of error [14].

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Proprioceptive assessments using goniometric error measurements have demonstrated acceptable to excellent test-retest reliability (ICC = 0.61–0.95) [15].

Stereognosis

Nine objects were introduced for the stereognosis assessment. The objects were first shown to the participant and then presented to them. With their vision obstructed, the participants were given the objects to hold and asked to name them. The number of objects correctly identified by the participant was calculated as points [16]. An abeslank (a flat wooden stick used as a standardized tactile stimulus) was used to assess stereognosis in the feet. The abeslank was placed horizontally, vertically, and diagonally. Participants were asked to estimate the direction of the abeslank by touching it to the plantar surface of their foot. The number of correctly identified directions was calculated as points [17]. Stereognosis has been identified as a clinically relevant assessment tool for children with CP [18].

Assessment of Body Awareness

Body awareness was assessed using a multisensory afferent model. This model consists of three components: a body schema representing the body's orientation in space, a structural description of the body including the topological organization of body parts, and a body image encompassing lexical-semantic and intrinsic-sensory information about the body. The body schema was assessed through tasks involving the imitation of meaningful and meaningless gestures; the structural description through tasks involving visual and verbal body part localization and matching body parts by location; and the body image through tasks involving matching body parts by function, matching body parts with objects, and naming body parts. All tasks were scored with 1 point for each correct answer and 0 points for each incorrect answer. The body awareness assessment battery has demonstrated good interrater reliability in children with CP [19].

Assessment of Activity, Participation and Quality of Life

The Child and Adolescent Scale of Participation (CASP)

The CASP questionnaire was used to assess participation. CASP is a scale that evaluates the participation of children and adolescents aged 6-21 in activities of daily living. CASP consists of 20 questions in total, categorized under ‘’Home participation, Community participation,

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Neighborhood and Community participation, School participation, and Home and Community activities’’. Rating is given on a scale of 0-4, expressing levels such as "expected for their age (full participation), somewhat limited, very limited, unable to participate, and not feasible. Higher scores indicate better participation. The validated Turkish version was used. The CASP has demonstrated good test-retest reliability (ICC = 0.94) and excellent internal consistency ($\alpha \geq 0.96$) [20].

Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDI-CAT)

PEDI-CAT is a computer-based scale developed to assess the daily living performance and functional skills of children and adolescents aged 6-20 years. PEDI-CAT uses a platform with a database of 276 items across four areas: "Daily Activities, Mobility, Social/Cognitive, and Responsibility" [21]. The PEDI-CAT has demonstrated excellent test-retest reliability (ICC = 0.96–0.97) and internal consistency ($\alpha = 0.99$) [22].

KIDSCREEN-27 Survey

KIDSCREEN-27 is a self-report questionnaire developed to measure health-related quality of life in children and adolescents. This scale is administered to children and adolescents aged 8-18 years. Comprising 5 dimensions and 27 items, the scale assesses the following areas: Physical well-being, Psychological well-being, Autonomy and parent-child relationships, Social support and peer relationships, and School environment. Items in the questionnaire are answered using a 5-point Likert scale, and children are asked about their experiences in the past four weeks. Higher scores indicate better health-related quality of life. The validated Turkish version was used. The Turkish version of KIDSCREEN-27 demonstrated acceptable to excellent test-retest reliability for all subdomains in children with CP (ICC = 0.71–0.97) [23].

Statistical Analyses

Before the analyses, descriptive findings were examined separately according to whether the variables were continuous or categorical. The normality distribution of the data was examined using the Shapiro-Wilk test to determine whether parametric or non-parametric methods should be applied. Spearman’s rank correlation analysis was used to examine associations between continuous variables, as the data did not meet the assumptions of parametric testing. To account for multiple comparisons, the Holm correction was applied to all correlation analyses. The number

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of comparisons was determined by the number of domains within each outcome measure (PEDI-CAT: k = 4, CASP: k = 5, KIDSCREEN-27: k = 6). The Holm procedure adjusts the significance threshold sequentially from the smallest to the largest p value while controlling the familywise error rate. Associations were considered statistically significant only when the corrected p value fell below the Holm-adjusted threshold. Additionally, only correlations in the expected direction were considered clinically meaningful and reported.

RESULTS

A total of 43 children with Hemiplegic CP were included in the study. The mean age of the participants was 12.65 ± 3.74 years (range:6–17). Of the participants, 21 (48.8%) were girls and 22 (52.2%) were boys. Additionally, 19 participants had right-sided involvement (44.2%) and 24 (55.8%) had left-sided involvement. According to functional classification systems, participants were distributed across different functional levels. Functional classification levels and detailed demographic characteristics are presented in Table 1.

Descriptive statistics of somatosensory functions and body awareness variables are presented in Table 2. Tactile perception thresholds and two-point discrimination values were reported as median (IQR) due to non-normal distribution, while vibration, proprioception, stereognosis, and body awareness scores were normally distributed and reported as mean ± SD.

Associations between somatosensory functions, body awareness, and activity performance measured by PEDI-CAT are presented in Table 3. Following Holm correction for multiple comparisons (k = 4 domains), eight statistically significant associations were identified. Vibration perception at the hand 1st PIP demonstrated a moderate positive correlation with the Daily Activities domain ($\rho = 0.385$, $p = 0.011$). Foot stereognosis showed moderate positive correlations with the Social/Cognitive ($\rho = 0.458$, $p = 0.002$) and Responsibility domains ($\rho = 0.396$, $p = 0.009$). Among body awareness components, body image score was moderately correlated with the Responsibility domain ($\rho = 0.432$, $p = 0.004$). Structural body representation demonstrated moderate positive correlations with the Daily Activities ($\rho = 0.393$, $p = 0.009$), Social/Cognitive ($\rho = 0.372$, $p = 0.014$), and Responsibility domains ($\rho = 0.514$, $p < 0.001$). Body schema score showed a moderate positive correlation with the Responsibility domain ($\rho = 0.469$, $p = 0.002$). No

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statistically significant associations were found between tactile perception, two-point discrimination, or proprioception and any PEDI-CAT domain following Holm correction.

Associations between somatosensory functions, body awareness, and participation outcomes measured by CASP are presented in Table 4. Following Holm correction for multiple comparisons (k = 5 domains), ten statistically significant associations were identified. Vibration perception at the foot 1st metatarsal ($\rho = 0.404$, $p = 0.007$) and medial malleolus ($\rho = 0.400$, $p = 0.008$) demonstrated moderate positive correlations with school participation. Body awareness measures demonstrated the strongest and most consistent associations with participation outcomes. Structural body representation showed significant positive correlations with home participation ($\rho = 0.486$, $p = 0.001$), community participation ($\rho = 0.603$, $p = 0.001$), home and community activities ($\rho = 0.569$, $p = 0.001$), and total CASP score ($\rho = 0.697$, $p = 0.002$). Body schema score demonstrated significant positive correlations with home participation ($\rho = 0.565$, $p < 0.001$), community participation ($\rho = 0.618$, $p < 0.001$), home and community activities ($\rho = 0.362$, $p = 0.017$), and total CASP score ($\rho = 0.608$, $p < 0.001$). No statistically significant associations were found between tactile perception, two-point discrimination, proprioception, or stereognosis and any CASP domain following Holm correction.

Correlations between somatosensory functions, body awareness, and quality of life measured by KIDSCREEN-27 are presented in Table 5. Following Holm correction for multiple comparisons (k = 6 domains), three statistically significant associations were identified in the expected direction. Two-point discrimination at the foot heel demonstrated a moderate negative correlation with the Physical Activities and Health domain ($\rho = -0.437$, $p = 0.003$), indicating that smaller discrimination distances were associated with better physical well-being. Proprioception error at hip extension showed a moderate negative correlation with the same domain ($\rho = -0.453$, $p = 0.002$), reflecting that smaller proprioceptive errors were associated with better physical well-being. Hand stereognosis demonstrated a moderate positive correlation with Physical Activities and Health ($\rho = 0.443$, $p = 0.003$). No statistically significant associations were found between vibration perception, body awareness measures, or tactile perception and any KIDSCREEN-27 domain following Holm correction.

DISCUSSION

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This study examined the relationships between somatosensory functions, body awareness, and functional outcomes across activity, participation, and quality of life domains in school-aged children with hemiplegic CP. The findings indicate that somatosensory dysfunction and impaired body awareness are not peripheral features of CP but are significantly associated with limitations in daily activities, restricted participation, and reduced quality of life. These results reinforce the growing view that CP should not be conceptualized solely as a motor disorder, but rather as a condition involving disrupted sensory, perceptual and motor integration.

Vibration perception at the hand 1st PIP was positively associated with the Daily Activities domain of PEDI-CAT. This finding highlights the potential contribution of somatosensory processing to functional performance in children with hemiplegic CP. Many daily activities depend on the accurate integration of sensory information to guide hand use and object manipulation. Consequently, preserved vibration perception may indicate more efficient processing of sensory feedback, supporting the performance of routine functional tasks. Although the observed association was limited to a single activity domain, it suggests that somatosensory integrity may influence children's ability to perform everyday activities beyond the effects of motor impairments alone. [24].

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Foot stereognosis demonstrated a significant positive correlation with Social/Cognitive and Responsibility of PEDI-CAT domains. This is consistent with findings by Myer et al., who reported that reduced plantar sensitivity negatively affected postural responses and motor performance [25]. Although stereognosis has been primarily assessed in the upper extremities in children with hemiplegic CP, the results of our study highlight the importance of tactile object recognition ability in the lower extremities. The plantar surface of the foot provides continuous sensory input during interaction with the environment, and the ability to identify and interpret tactile stimuli applied to this region may reflect broader somatosensory integration capacity. Such integrated sensory processing may support adaptive cognitive-social behaviors required in daily life, including environmental navigation, peer interaction, and management of school-related activities. From a rehabilitation perspective, these findings may indicate that assessment of lower extremity stereognosis could provide additional insight into sensory-perceptual functioning in children with hemiplegic CP and may represent a clinically relevant component of comprehensive intervention approaches.

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Body awareness measures, particularly structural body representation, demonstrated the most consistent associations with PEDI-CAT domains. Structural body representation was related to Daily Activities, Social/Cognitive functioning, and Responsibility, whereas body schema and body image were associated only with the Responsibility domain. These findings suggest that higher-order representations of the body may contribute to functional performance beyond the influence of isolated sensory modalities. Marsico et al. reported associations between lower extremity body awareness and movement selectivity, walking capacity, and functional performance in children with upper motor neuron lesions [26]. Similarly, Di Vita et al. showed that impaired body awareness in children with CP may negatively influence activities of daily living [27]. The Responsibility domain reflects a child's capacity to independently manage personal care routines and health related decisions, competencies that depend not only on intact motor function but also on a coherent sense of one's own body. When body image is disrupted, as is commonly observed in hemiplegic CP, children may experience difficulties in organizing, initiating, and monitoring their own daily activities. In line with this, Fontes et al. emphasized that alterations in body representation in children with hemiplegic CP extend their functional impact beyond motor performance into broader domains of daily functioning [19]. Taken together, these findings point to the potential value of incorporating body awareness focused interventions into rehabilitation programs aimed at promoting functional independence in this population.

In the present study, both vibration perception and body awareness measures were associated with participation outcomes. While vibration perception at the foot was specifically related to school participation, structural body representation and body schema demonstrated broader associations across home, community, and overall participation domains. These findings suggest that both sensory processing and higher-order body representations contribute to participation in children with hemiplegic CP. However, the more consistent associations observed for body awareness measures indicate that the integration and representation of bodily information may play a particularly important role in children's participation in everyday life situations.

The association between foot vibration perception and school participation may reflect the contribution of lower-extremity somatosensory input to participation-related outcomes in children with hemiplegic CP. Sensory information arising from the foot and ankle plays an important role in postural control and the adaptation of movement to environmental demands. Consistent with

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our findings, Zarkou et al. reported that vibration perception at the first metatarsal head was significantly associated with motor performance, gait parameters, functional mobility, and muscle strength in children with hemiplegic CP (10). Given that successful participation in school settings requires effective mobility and interaction with the surrounding environment, preserved vibration perception may facilitate engagement in school-related activities.

Significant associations were identified between body awareness measures and multiple participation domains assessed by the CASP. Among the body awareness components examined, both structural body representation and body schema demonstrated significant positive associations with total CASP score, highlighting the relevance of higher-order body representation processes in real-world participation outcomes. Previous research has shown that changes in body image can negatively affect environmental interaction and social perception in children with CP [28]. Similarly, Di Vita noted that distortions in body representation may lead to difficulties in functional interaction with the environment [27]. Since participation in daily life requires continuous integration of multisensory input, motor planning, and adaptive interaction with the environment, impairments in body awareness may influence overall participation and engagement in children with hemiplegic CP. The broad associations observed across home, community, and overall participation domains further suggest that higher-order body representation processes may support children's involvement in a wide range of real-life situations.

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The findings related to quality of life indicate that somatosensory function may be particularly relevant to children's perceptions of physical well-being. Tactile discrimination, proprioception, and stereognosis were all associated with the Physical Activities and Health domain of KIDSCREEN-27, suggesting that efficient processing of sensory information may contribute to how children perceive their physical capabilities and health status.

A noteworthy finding was that the associations observed for tactile discrimination and proprioception were both confined to the Physical Activities and Health domain of KIDSCREEN-27. Although these measures represent different components of somatosensory function, their associations converged on the same quality-of-life domain. This pattern may indicate that somatosensory impairments are reflected most consistently in children's perceptions of physical functioning and health status. The absence of associations with other KIDSCREEN domains

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further suggests that sensory deficits may have a more direct impact on perceived physical well-being than on broader psychological, social, or environmental aspects of quality of life.

Hand stereognosis was also positively associated with the Physical Activities and Health domain of KIDSCREEN-27. As a higher-order somatosensory function, stereognosis requires the integration and interpretation of tactile information. Previous studies have suggested that children with CP may develop altered bodily experiences and perceptions related to their physical limitations and interactions with the environment [29–30]. Difficulties in tactile perceptual processing may influence how children perceive and interact with their environment during everyday activities, potentially affecting their engagement in physical activities and health-related functioning. Therefore, the present findings suggest that somatosensory assessment, particularly stereognosis, should be considered not only in the context of motor and functional outcomes, but also as a potential contributor to the physical dimension of quality of life in children with hemiplegic CP.

Several limitations of the present study should be acknowledged. First, although Holm correction was applied to reduce the risk of type I error, the combination of multiple comparisons and a relatively modest sample size may have reduced statistical power and limited the detection of moderate associations. Therefore, some potentially meaningful relationships may not have remained statistically significant after adjustment. Second, the cross-sectional design precludes causal interpretations regarding the relationships between somatosensory functions, body awareness, and activity, participation, and quality-of-life outcomes. Third, although comparisons with typically developing peers were conducted within the broader study project, the correlation analyses presented here were limited to children with hemiplegic CP. Finally, activity, participation, and quality of life are multidimensional constructs influenced by motor, cognitive, psychosocial, and environmental factors beyond somatosensory functioning alone. Future studies with larger samples and longitudinal designs are needed.

In conclusion, the present study suggests that higher-order sensory-perceptual functions, particularly body awareness and stereognosis, may be more closely associated with activity, participation, and quality of life outcomes in children with hemiplegic CP than basic sensory modalities alone. These findings support the growing perspective that CP should not be

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conceptualized solely as a motor disorder, but rather as a condition involving complex sensory-perceptual-motor interactions. From a clinical perspective, assessment of sensory-perceptual functioning may provide additional insight into daily life functioning and may represent important targets for comprehensive rehabilitation approaches. Further studies with larger samples are needed to better clarify the role of sensory-perceptual processes in functional outcomes in children with hemiplegic CP.

Conflict of Interest:

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Data Availability The datasets generated and/or analysed during the current study are not publicly available due to ethical restrictions involving pediatric clinical data and institutional regulations at Hacettepe University but may be available from the corresponding author upon reasonable request.

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TABLES

Table 1. Demographic and Clinical Characteristics of the Study Sample

Variable	Total (n=43)
Age (years)	**12,65 ± 3,74 (6-17)**
Sex, n (%)	
Girls	21 (48.8%)
Boys	22 (52.2%)
Side of involvement, n (%)	
Right-sided hemiplegia	19 (44.2%)
Left-sided hemiplegia	24 (55.8%)
GMFCS level, n (%)	
Level I	15 (34.9%)
Level II	25 (58.1%)
Level III	3 (7.0%)
MACS level, n (%)	
Level I	9 (20.9%)
Level II	16 (37.2%)
Level III	18 (41.9%)
CFCS level, n (%)	
Level I	34 (79.1%)
Level II	9 (20.9%)
EDACS level, n (%)	
Level I	37 (86.0%)
Level II	6 (14.0%)

Values are presented as mean ± standard deviation or n (%). Abbreviations: GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System; EDACS, Eating and Drinking Ability Classification System.

Table 2. Descriptive Statistics of Somatosensory Functions and Body Awareness Variables

Sensory Assessments	Median (IQR)	Sensory Assessments	Mean ± SD
Tactile perception (level)		**Vibration (s)**	
1st phalanx	2,83 (2,83-6,65)	**1st phalanx PIP**	5.40 ± 2.44 (1.03-11.00)

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5th phalanx	2,83 (2,83-6,65)	**5th phalanx PIP**	5.39 ± 2.29 (1.16-11.38)
Palm	2,83 (2,83-6,65)	**Ulna**	5.06 ± 2.22 (1.05-9.74)
1st metatars	3,61 (2,83-6,65)	**1st metatars**	4.76 ± 1.87 (1.45-10.00)
5th metatars	3,61 (2,83-6,65)	**Medial malleolus**	4.61 ± 1.63 (1.33-7.04)
Heel	2,83 (2,83-6,65)	**Lateral malleolus**	4.75 ± 1.99 (1.22-11.56)
Two-point discrimination (mm)		**Proprioception (degree)**	
1st phalanx	8 (2-8)	**Shoulder flexion**	23.65 ± 5.51 (11.30-35.00)
5th phalanx	8 (2-8)	**Shoulder extension**	11.94 ± 3.33 (4.70-16.90)
Palm	7 (2-8)	**Shoulder abduction**	23.51 ± 6.84 (8.00-35.20)
1st metatars	8 (2-8)	**Hip flexion**	23.95 ± 5.99 (11.00-35.10)
5th metatars	8 (2-8)	**Hip extension**	12.05 ± 3.19 (4.30-18.70)
Heel	8 (2-8)	**Hip abduction**	22.70 ± 7.37 (8.00-32.90)
		Stereognosis (identified object number, n)	
		Hand	6.35 ± 2.46 (1-9)
		Foot	4.67 ± 2.11 (1-9)
		Body awareness (number of tasks completed correctly, n)	
		Body image	16.70 ± 1.97 (10-18)
		Structural description of body	18.60 ± 1.88 (12-20)
		Body schema	19.07 ± 1.61 (13-20)

Those parameters with normal distribution are shown as x ± SD, and those with non-normal distribution are shown as Xmed (lower value–upper value). x: arithmetic mean; SD: standard deviation; Xmed: median; PIP: proximal interphalangeal joint.

Table 3. Correlations Between PEDI-CAT Domains and Sensory Functions and Body Awareness Measures

Sensory Domain and Body Awareness Part	Measurement	PEDI-CAT Domain	r	p
Vibration	Hand 1st PIP	Daily Activities	0.385	**0.011***
Stereognosis	Foot	Social/Cognitive	0.458	**0.002***
Stereognosis	Foot	Responsibility	0.396	**0.009***
Body awareness	Body image score	Responsibility	0.432	**0.004***

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Body awareness	Structural representation	Daily Activities	0.393	**0.009***
Body awareness	Structural representation	Social/Cognitive	0.372	**0.014***
Body awareness	Structural representation	Responsibility	0.514	**<0.001***
Body awareness	Body schema score	Responsibility	0.469	**0.002***

PEDI-CAT: Pediatric Evaluation of Disability Inventory Computer Adaptive Test. Only statistically significant correlations after Holm correction are shown (correct direction only). *$p < 0.05$ (Holm corrected; k = 4 PEDI-CAT domains per sensory measure). Spearman's rho (ρ), n=43.

Table 4. Correlations Between CASP Domains and Sensory Functions and Body Awareness Measures

Sensory Domain and Body Awareness Part	Measurement	CASP Domain	r	p
Vibration	Foot 1st metatarsal	School Participation	0.404	**0.007***
Vibration	Foot medial malleolus	School Participation	0.400	**0.008***
Body awareness	Structural representation	Home Participation	0.486	**0.001***
Body awareness	Structural representation	Community Participation	0.603	**0.001***
Body awareness	Structural representation	Home & Community Activities	0.569	**0.001***
Body awareness	Structural representation	Total Score	0.697	**0.002***
Body awareness	Body schema score	Home Participation	0.565	**<0.001***
Body awareness	Body schema score	Community Participation	0.618	**<0.001***
Body awareness	Body schema score	Home & Community Activities	0.362	**0.017***
Body awareness	Body schema score	Total Score	0.608	**<0.001***

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CASP: Children and Adolescent Participation Scale. Only statistically significant correlations after Holm correction are shown (correct direction only). *p < 0.05 (Holm corrected; k = 5 CASP domains per sensory measure). Spearman's rho (ρ), n=43.

Table 5. Correlations Between KIDSCREEN-27 Domains and Sensory Functions and Body Awareness Measures

Sensory Domain and Body Awareness Part	Measurement	KIDSCREEN-27 Domain	r	p
Two-point discrimination	Foot heel	Physical Activities & Health	-0.437	**0.003***
Proprioception	Hip extension difference	Physical Activities & Health	-0.453	**0.002***
Stereognosis	Hand (known objects)	Physical Activities & Health	0.443	**0.003***

Only statistically significant correlations after Holm correction are shown (correct direction only). *p < 0.05 (Holm corrected; k = 6 KIDSCREEN-27 domains per sensory measure). Tactile sensation was excluded due to unexpected correlation direction. Spearman's rho (ρ), n=43.

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